STRATEGY RESEARCH PROJECT

CONVENTIONAL INTERCONTINENTAL BALLISTIC MISSILES – NEW WEAPON, NEW WORLD

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ABSTRACT

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The U.S. Air Force is developing technology to place a variety of non-nuclear weapon payloads on intercontinental ballistic missiles (ICBMs). These conventional ballistic missiles (CBM) would provide indirect fire with a quick reaction capability on fixed and potentially mobile targets. The use of these weapons necessitates a change in international notification policy and climate for long range missile launches from the United States. The near-term deployment of these weapons creates the potential for accidental or retaliatory launches of nuclear-tipped missiles from Russia and China. Far-term deployment increases this risk. The paper points out several other problems with CBM deployment and suggests some mitigation strategies. While some of the mitigation aids are technological in nature, the paper stresses that a new climate must exist before the CBM can be seriously considered as a viable weapon.

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PREFACE

I became interested in this topic while sitting at a Joint Theater Air and Missile Defense Organization conference table in Crystal City during a coffee break. An Air Force Officer from Air Force Studies and Analysis mentioned the subject of long range conventional strikes and how the Air Force could use an ICBM for that role. I was immediately struck by the concept, which I thought would never have been considered seriously by DoD. The idea of a conventional ICBM made me remember an article I read in the early 90's discussing commercial sub-orbital launch vehicles. One of the problems with using rockets for commercial transport is the inherent problem of identification. Is the incoming rocket a nuclear-tipped missile, or is it just the 9:45 Beijing to Dulles Federal Express jump? The next few years should tell the tale with SeaLaunch, Roton Rotary Rocket, and other commercial rocket firms coming operational. I would like to thank Army Colonels Carl Roe and Calvin Lewis, and Air Force Colonel Paul Guzowski for their assistance in this editing this paper. Any errors in this document are mine alone.

CONVENTIONAL INTERCONTINENTAL BALLISTIC MISSILES - NEW WEAPON, NEW WORLD

Almost no one thinks of warfare with intercontinental ballistic missiles except in a nuclear sense. These weapons, almost by definition, are instruments of nuclear terror, of war gone mad, of civilization's end. Not surprisingly, it is extremely hard to think of using intercontinental ballistic missiles (ICBMs) in any other way. Nevertheless, and primarily since the end of the cold war, Air Force analysts give thought to using intercontinental ballistic missiles, missiles tipped with non-nuclear ordnance, in a conventional role.[1,2,3]

Serious discussion of conventional ballistic missiles (CBMs) dates only to the 1990s, likely related to the Strategic Arms Reduction Talks (START) agreement and the demise of the Soviet Union.[4] Ignoring technical articles and concept papers, policy literature discusses CBM employment only in regard to limited engagements. The reference work on CBMs is an Air Power Journal article written in 1993 by Lt. Col. James London. London focused on Operation EL DORADO CANYON, the 1986 raid on Libya, using that operation as the seminal use for CBMs. Inspired by London's paper, another Air Force Officer, Major Richard Patenaude, proposed specific roles of non-nuclear ICBMs in conventional deterrence, military operations other than war, and major theater wars.[5] Currently, the Air Force continues to pursue the concept, including a recent American Institute of Aeronautics and Astronautics paper, a requirements analysis effort with United States Space Command, and technology programs.[6,7,8]

While the Air Force efforts regarding conventional ICBMs may be intriguing, thinking about conventionally armed ICBMs should not be difficult. To date, all ballistic missiles employed in war carried conventional ordnance - not nuclear, biological or chemical ordnance. Placing conventional ordnance onboard an ICBM is simply a logical progression of precision guided munition (PGM) technology.

No one seriously doubts the practical use and utility of PGMs in warfare. No longer theoretical in application, PGM are demonstrably effective, and getting more so. Remember the U.S. attack on an Iraqi nuclear facility during the Gulf War.[9] The attack began using 32 F-16 attack aircraft with dumb bombs, 16 F-15 escorts, 12 F-111 Raven and F-4G jammer aircraft and 15 KC-135 tankers. No reactors were destroyed. Later, 6 F-117 with PGMs with two refueling tankers destroyed 3 of 4 reactors.[10] It is a comfortable assertion that four ICBMs with conventional munitions could range and destroy all four reactors.[11]

Ballistic missiles are fast, passing through all but the most sophisticated air defenses. Literature touts the ICBM's fast reaction time as a first-order characteristic.[12] Actually, the ICBM flight path, not flight duration, is its greatest asset. ICBMs do not violate sovereign air space of nations along the ground track - the complication during the El Dorado raid that indirectly caused the deaths of an F-111 crew.

While we have ignored sovereign airspace when it suits our interests, if given a choice, we would rather not.

Hence - speed is not everything. While the ICBM does bring phenomenal speed compared to strategic bombing from North America, considering the amount of time from a triggering event to wheels leaving the tarmac, a 30-minute flight time really does not enhance the value of retribution. And, as for that U.S. raid on a Sudanese pharmaceutical factory, that operation could have benefited from more analysis time, not less flight time. So time of flight, while important, is not the most important factor. It is the flight path.

An additional advantage of CBMs is the removal of pilots risking their lives on well-defended targets. Casualty aversion and force protection are always important, if sometimes overpowering, considerations. It does not stop with airmen and in-theater soldiers however. The next step down the pyramid is the reduction of weapon system manpower and supporting infrastructure. Air-launched and sea-launched cruise missiles (ALCM and SLCM) used in the Kosovo raids needed launching platforms, manpower to operate, overseas bases and ports.[13] Further down the pyramid is the force training, sustainment, and maintenance. An operational conventional ICBM base would likely be highly automated and robotic, with a single standardized airframe, storable liquid propellants, selectable warheads, capable of launching without gantries or silos. This centralization of strike capability on U.S. soil rather than projecting it in-theater promotes cost savings. Possible denial to U.S. access in-theater is another strength - continental basing.

Militarily useful conventionally armed ICBMs will be built, if not first by United States, then by another technological power. This paper identifies and examines some of the problems in deploying and using conventional intercontinental ballistic missiles. With these problems identified, we then describe the kind of international environment that must exist to allow deployment and use of this weapon type.

In the reminder of this paper, "CBM" stands for conventionally armed intercontinental ballistic missile, while "ICBM" stands for intercontinental ballistic missiles with nuclear warheads. With that, we begin discussions of some of the problems with CBMs.

PROBLEMS

Regardless of the tactical, operational and cost advantages of CBMs, when talking about their problems, most writers and commentators highlight problems associated with treaty or arms control limitations. Rarely do they undertake a thorough analysis of the problems identified with CBM deployment and employment. The problems identified here are by no means complete.

FIRST STRIKE WEAPON

The Russians have held a view that stationary strategic weapons (like an ICBM missile field) without defensive capabilities must be considered first strike weapons.[14] They assume missile silos do not need defense systems because the weapons will be used first, leaving nothing but empty silos to counter fire against. The MX missile is a system generally acknowledged as being vulnerable to an accurate first strike attack, as are Russian fixed-site ICBMs. A strategic weapon with a defense system however, such as an air defense ring, would not be considered in the first strike category, since it could technically ride out an attack.

There is no discussion in CBM proponent circles whether CBM farms need an air defense umbrella. Despite the lack of a nuclear warhead, there is nothing in current CBM concepts that make them any different from ICBMs from the Russian perspective. Therefore, weapons in this class not having an air defense network fit the Russian first strike weapon model.

IDENTITY UNCERTAINTY

Consider how it looks to a nation detecting a missile coming over the horizon in its direction. Is it a nuke or a conventional warhead in that missile coming over the horizon? This is an obvious CBM problem. This problem of uncertainty is not new to CBMs. During the 1980's, when PGMs were beginning to be deployed in large numbers in Europe, there was a concern about the Soviet reaction to a lone PGM headed in the direction of the WARSAW pact in the heat of battle.[15] How would they be assured that the incoming missile had a conventional warhead? The same problem applies to CBMs. In fact it is worse. All currently deployed ballistic missiles with intercontinental ranges have nuclear warheads today. Any CBM launch is bound to be provocative or at best, could cause a sense of grave unease.

ACCIDENTAL RESPONSE

If the United States deploys a CBM system, the CBM deployment site will come under even more scrutiny by other technologically advanced nations. That is because the likelihood of the U.S. using conventional weapons is significantly greater than for nuclear weapons. Consequently, Russia, China and other technologically capable nations will focus their technical means on us more, increasing the likelihood these countries would respond inadvertently to a valid CBM launch, or even normal space launch traffic. This is problem is akin to "jumping the gun" in a foot race. History does not give much comfort here. Russia has been surprised in the past by rocket launches, most notably on January 1995, when a Norwegian sounding rocket placed the Russian Strategic Rocket Forces on high alert.[16]

Here is another example of a false indication, this one caused by multiple stimuli. In November 1956, during the French and English attack on the Suez, Moscow issued a communiqué to London and Paris that rocket attacks were being considered against those cities. On the same night, U.S. forces in Europe received a flash message that unidentified aircraft were seen over Turkey, placing Turkish forces on alert. Reports also said there were Soviet MIGs over Syria and that a British Canberra bomber was shot down, implying a MIG was involved with its downing. To top it off, the Russian fleet was moving through the Dardanelles. Under these conditions, the NATO operational plan of the period called for nuclear strikes against the USSR. What actually happened was the Soviet fleet was on a previously announced exercise, the Syrians were returning from a state visit to Moscow, the Canberra was downed via a mechanical problem, and the planes seen on radar were geese.[17]

Another accident occurred during the Cuban missile crisis. A radar operator inadvertently played a simulation of a missile firing from Cuba aimed at Tampa. The operators waited for the detonation that, to their great relief no doubt, did not occur. Other false alarms occurred in 1979 and 1980, each having to do with missile launch detection false alarms.[18] Considering the Soviets and the United States operated under "launch under attack" protocols and, for the Soviets at least, a policy permitting launch when Soviet leadership has been destroyed,[19] the world has been lucky so far.[20]

By comparison, CBMs launched today would not be geese mistaken for fighter aircraft, a scientific sounding rocket, or a malfunctioning nuclear command and control computer – they would be real. Thus, in light of current or projected foreign early warning systems, using CBMs is ill advised.[21]

UNINTENDED ESCALATION

There is a perception difference between a B-2 from Missouri heading out on a mission and a Missouri-based CBM launched with the same aim point. A CBM launch is more provocative than a bomber. Such a launch would signal a new level in an ongoing conflict, or exceed the opponent's threshold for retaliatory strikes. Moreover, if CBMs will be as good as proponents tout, other nations will begin to view them as viable strategic weapons in their own right. Defense commentators in the 1980s believed conventional and nuclear weapon distinctions would blend together as PGM became more available and more capable.[22] So as PGMs improve, the interface between conventional and nuclear weapon diminishes.[23] CBMs have potential capability to destroy fixed ICBMs more efficiently than any nuclear weapon could.[24] Indeed, China and Russia both consider PGMs as weapons on par with nuclear weapons. Consequently, a CBM strike against Russian or Chinese homelands with may well invoke their use of weapons of mass destruction. As we shall later see, CBMs will require maneuvering warheads, so a CBM headed towards a non-strategic target in their heartland may in fact be bound for an ICBM field. Or, it may be headed towards a nuclear command and control node for a decapitation strike. A CBM

rising generally towards their heartland may thus prompt a strong response early in the CBM's trajectory. Retaliation or escalation may come from a nation's own strategic nuclear weapons, to terror attacks against our deployed personnel or personnel on our own continent. In other words, deployment of CBMs blurs the strict distinction between nuclear and conventional weapons, perhaps edging us closer to the use of nuclear weapons in the battle.

TARGET NATIONS

What if the United States declares a policy not to use nuclear weapons against other nuclear weapon states? With this policy in place, CBM proponents contend that CBMs should not be used against nuclear-capable states, since the bulk of our nuclear weapons sit atop ballistic missiles. Then whom are the CBMs to be used against: rogue terrorists, roaming inside failing or failed states? One should pause and think of the monetary and operational implications of building weapon systems that, from a policy perspective, cannot be used against countries that threaten U.S. security. Instead, we should build weapons that we can use against them, if we view these states as threats.

BYSTANDERS

A CBM used to its fullest potential could inflict considerable damage while allowing little time for the target to react. Patenaude talks of decapitation when employing CBMs in a major theater war (MTW), with particular attention to senior-level command and control posts.[25] In an MTW, such as a Korean conflict with China as a sympathetic bystander or observer, a number of CBMs detected coming over the horizon would likely look very menacing. China and any other nation would be confident that the CBMs had very accurate conventional warheads. It is not a secret that the U.S. has tested maneuvering re-entry vehicles on ICBMs. These weapon carriers have significant cross-range capability. Accordingly, a bystander or sympathetic nation in an ongoing MTW could be drawn into the conflict because it could not accurately determine the target of the warhead. Observer nations would not know the target until the last few minutes of the flight. They might not wait to find out.

CONVENTIONAL ARMS RACE

Arms control proponents argue that the U.S. nuclear arsenal is too big to justify. Therefore, deterrence might rest with conventional rather than nuclear forces. Switching from nuclear to conventional strategic weapons though may not reduce the fear factor when the replacement weapon is equally lethal to a nuclear weapon. Nations are concerned about their survival, not which types of weapons are used to threaten them. For example, the Chinese government places great importance on having nuclear weapons because such weapons grant superpower status. A U.S. military strategy in which CBMs have a prominent role would heighten China's anxiety. China's fears of PGM and high

technology weapons center around third world countries developing chemical or biological weapons as a poor man's reply to American PGMs.[26] American CBMs would only reinforce this concern. Moreover, there is talk that while Americans will not themselves die in wars, Americans have no second thoughts sending killing machines as their proxy. This goes far in explaining why the Chinese view national missile defense and PGMs with alarm.[27] But we should not restrict our focus to China. Ballistic missiles, Aaron Karp argues, have a psychological value that outweighs their inferiority against cruise missiles from a payload carrying perspective.[28] Because of this psychological value, nations will seek to acquire and use them. CBM deployment fans these flames of fear.

COASTAL RANGE BASING

Current thinking places CBM launch sites at both the Eastern and Western Test Ranges, under the premise that locating CBM farms far away from ICBM silos reduces the chance of misidentification. Both ranges will have significant commercial space activities in the future; even the Western Test Range used for polar launches.[29] As launch rates rise and launch costs fall, we can begin to see the lifting of launch inclination angle on the western range restrictions, permitting flights over populated areas. If we take as a given increased commercial space traffic, does the U.S. really want to place an offensive war fighting capability at a commercial spaceport? Locating a strategic weapon launch facility adjacent to a spaceport is senseless.

Coastal basing produces a variation of the misidentification problem. And how would a bystander or aggressor know if a missile launch were a commercial vehicle or CBM? They might not believe published launch schedules, or threaten not to during a conflict. It is an invitation for a preemptive strike, likely involving collateral damage on the commercial space sector.

Security is another problem with basing on the coastal CBM ranges. With the growth of commercial space launch activity over the next few decades, more people and equipment will be near a weapons firing range. In particular, consider the location of the eastern test range, where the population continues to expand. All launches from Cape Canaveral are visible from Orlando.[30]

Hawaiian basing is also not a realistic option. Hawaiian environmental impact studies would be extensive. The Barking Sands flight test area at Kauai has had trouble with environmental concerns.[31] Placing a major CBM launch facility on the leeward sides of Kauai or Oahu would likely face stiff resistance by the local population. The only clear advantage having CBM facilities on the coasts or Hawaii is the relative lack of concern over staging debris.

FLYOVER DEBRIS

Current CBM concepts use old Minuteman propulsion sections or motors, essentially refitting old ICBMs with new warheads. Because the purpose of these platforms was to fight a nuclear war, where the rocket booster fell during flight was not a factor. In a conventional role, where these boosters drop is an issue. These solid rocket motors do not throttle, so trajectory shaping must be considered. This trajectory shaping may cause stages to drop in unintended or undesired locations. If a CBM were coastally based, the first stage would probably splash into the sea, with second and third stages burning up upon atmospheric reentry. CBMs based at interior locations would drop their boosters within the continental U.S. For any other basing location and for all possible ranges, the booster drop locations should be examined closely.

COSTS

We must view with skepticism certain published statements concerning building ICBMs based on lowest cost.[32] The track record for building rockets based on lowest cost is not impressive. The commercial launch industry has every incentive for lower launch costs, unlike the nuclear weapons community.[33] First, the space lift industry, the same industry tasked to build ICBMs, has not delivered on concepts to significantly reduce costs. Second, a CBM requires technology within the warhead section just a complex as any other PGM, perhaps more so. It is doubtful a CBM with a 900 kilogram conventional warhead fitted with terminal guidance can be purchased any time soon for less than $100,000 – the magic number for cost effective PGMs.[34] From a rogue nation's weapon costing perspective, the CBMs will look attractive only when they can be acquired for less than that of a ground-launched cruise missile.

NUMBERS

Finally, the START treaty limits the U.S. to no more than 1750 land-based ballistic missiles.[35] The treaty does not distinguish between missiles tipped with nuclear and conventional warheads. If the U.S. deploys CBMs, what numbers of ICBMs do we trade off for CBMs? Will the American public accept such a weapon tested and based in the U.S. when the majority of them grew up in a world where long range ballistic missiles equated with nuclear war? Use of these weapons would require an ability to replace them rapidly, something quite possible if low cost production were truly achieved. It is likely we would have to provide access to CBM production facilities by the Russians to insure the U.S. could not breakout of the START II ICBM limit.

So, within the current international security environment, CBMs emphasize attributes of ICBMs while creating new problems related to basing, staging debris, strategic weapons employment doctrine

and associated policy formulation. The problems presented above probably do not present the full accounting. Or other problems might just be twists on the above. Clearly, CBMs will not find a place in our current world. What is needed is to move towards a new world where CBMs may have a place for the war fighter. If we believe the advantages of CBMs are not chimerical, let us now consider ways to allow CBM deployment to create this new world.

MITIGATORS

By mitigators, we are looking for technologies, policies, and procedures that will allow the use of CBMs in all applicable aspects of warfare, from a single operation other than war to multiple theater wars. Of these, technologies lead as the forcing function for new policies and procedures.

INTERNATIONAL SECURITY ENVIRONMENT

There are four points to consider when talking about the future of strategic and regional conflicts.[36] First, military and space technologies will continue to provide the means for precise, discriminating attacks at global ranges. Second, 21st century warfare will continue to be less about mobilization than about military forces-in-being. Third, critical economic, military and political powers are becoming concentrated and fragile within developed nations. Fourth, the use of nuclear weapons as a political and military instrument is becoming less likely. These four points frame the future, introducing thought processes that show why CBMs will be introduced, serving as one of many PGM weapons in future conflicts.

The first point noted above relates to the CBM itself, a trend evident since the 1970's that continues even now. No one expects this trend to level out. The point is practically subconscious.

The second point noted above implies that nations, such as the U.S., have to maintain military forces continuously to be of any use in future conflicts. But as a result of the first point, manpower is becoming less important to prosecute warfare. What military forces we have in being must be able to react quickly and decisively, without having to be mobilized, indoctrinated or deployed. Long range PGMs based in the continental U.S. fit this mold, especially CBMs. And we will continue to use of commercial technologies adapted to military ends. This includes technologies such as cell telephones and over-the-counter encryption for communications, and commercial aerial robotics for PGM delivery. On the economic side, the U.S. is currently having trouble manning its armed forces because of a robust private sector. Unless military service is monetarily advantageous or a pandemic of patriotic altruism set in, our active and reserve military forces will continue to shrink. Substantially raising military compensation or the public conscience in favor of military service is doubtful.

The third point noted above can be seen in this country and Europe. These two economic blocs cannot function normally without power production facilities, roads, bridges, ports, airfields, and cyber infrastructure. A fire in a Taiwanese chip production plant can directly affect prices for computer goods in the U.S. The destruction of the vehicle tunnels and bridges into New York City's Manhattan borough would seriously affect operations on Wall Street. No one can dispute seriously these three points. The fourth point noted above allows a series of actions and activities bringing CBMs and other new types of PGMs into use into the 21st century.

NUCLEAR ARMS REDUCTION AND ARMS CONTROL

It is highly unlikely the U.S. will every again use nuclear weapons in war. This topic is a popular one in seminars within the Army War College. The only likely scenario for such employment is one by a rogue nation during an ongoing MTW. Even in this scenario, it is doubtful the U.S. would call a nuclear strike. The nation receiving the strike is composed of innocents, even if some are in the military. Second, the political and military leaders who called the strike against the U.S. would not be, in all likelihood, on the receiving end of the attack. They would be in a location confident the U.S. would not drop a nuclear bomb on, and likely flee the country in short order, since their attack would certainly mean the end of their government. Third, the international community would denounce us for using a nuclear weapon against a population or army that did not have a voice in the use of a nuclear weapon against the U.S.

Besides the international outcry and embarrassment from the above scenario, never mind the immorality of the attack, what is the U.S. going to do about the attack's aftereffects? Certainly the U.S. would consider damage both against the aggressor nation and collaterally in the war plan.[37] The country's infrastructure would likely collapse shortly after the attack. We would have to consider occupation forces, reconstruction, and humanitarian relief in addition to radiological concerns from a nuclear attack, adding additional expenses to an already expensive operation.

If we are not going to use nuclear weapons (and the rest of the developed world shares this position) we would do well to drastically reduce these weapons, as they cause angst between nations. The U.S. could maintain a smaller force of nuclear weapons based in submarines – an ample number as insurance against a counter strike capability in the event of an nuclear confrontation against a resurgent Russia, a bellicose China, or a well-armed irrational nation or organization. Elimination of ICBMs solves most of the misidentification concerns. Taken further, the reduction of nuclear weapons would ease world tensions, and while not eliminating war, it would allow more precise and non-catastrophic strife room to maneuver. However unfortunate it is, the effective elimination of the nuclear option allows nations to conduct aggression much in the manner as they have in past millennia, albeit with better weapons. A good first step towards reducing nuclear tensions would be unilaterally meeting or exceeding START III

nuclear force levels, regardless of foreign reactions or intentions, with the added benefit of strengthening non-proliferation treaties and possibility reviving a comprehensive nuclear test ban.

To make CBM deployment more acceptable, we could go further by declaring a "no first use" pledge, instead of our current policy of non-specific massive retaliation. We would not be the first nation to do so. China in December 23, 1993 proposed negotiations be started on a no-first use treaty, and stated so again in March 1994.[38] If the U.S. wants to exploit future CBMs and other long range PGMs, a no-first use pledge would be prudent.

Taking this further, if CBMs and other PGMs can really replace nuclear weapons, why should nations maintain nuclear weapons if not to destroy cities and their populations? Alan Builder, an analyst associated with the Brookings Institution, makes this argument against nuclear weapons.[39] Regrettably, most nuclear analysts and commentators recognize the U.S. could field "clip-on" nuclear weapons - rendering most military air platforms into nuclear delivery vehicles. This type of technology does not assist in the deployment of CBMs since clip-on nuclear weapons effectively allows any long range vehicle to be a strategic nuclear delivery vehicle. However, the U.S. already developed small nuclear weapons and precision delivery vehicles are a trend occurring with or without CBMs.

COUNTER PROLIFERATION

From an arms control perspective, the CBM is different from nuclear weapons in that these weapons do not threaten national survival. Though the effects of a massive CBM barrage should not be taken lightly, CBMs would not obliterate the populace and industry as nuclear weapons could.

CBM opponents may argue that using CBMs increase the likelihood that nations other than China and Russia will field long range missiles. However, arms proliferation in the CBM context is entirely different from nuclear weapons. The difficult part of the CBM is the warhead and reentry vehicle, not the launch vehicle.[40] To be useful in delivering a penetrator, the warhead must come within a few feet of the target. This is impossible using inertial guidance alone because of weather and guidance system errors. The existence of CBMs does not promote proliferation of weapons of mass destruction. Instead, CBMs are neutral on this point.

A common position arms control analysts hold is that nations pursue ballistic missile and nuclear weapons technology because of prestige. However, what if rockets become more common tomorrow than today? Will missiles still have the same status or appeal?[41] If rocket technology becomes ubiquitous, the "status" of the long range rocket may decline. Because the CBM does not display raw power like thermonuclear power does, it is less desirable as a "status" or a weapon of terror by an

authoritarian or rogue state. As for the possibility of chemical or biological warheads on intercontinental ballistic missiles being a weapon of "raw power"; their effects are too unpredictable, take too long to manifest on the target (for biological warheads), can be delivered more effectively by other means, and could be dealt with a competent civil response regime. The next proliferation risk may lie with nanotechnology, gene splicing, and information operations, rather than long range missiles, because of their wide spread availability and private research activity,

TECHNOLOGICAL

Nuclear weapon monitoring technology assists with CBM deployment by differentiating land-based ICBMs from CBMs. One example is the placement of silo door alarms over current Minuteman and Peacekeeper sites. Other measures could be video monitoring of the area. This type of monitoring makes sure that, even if a CBM were in flight, aggressors and other nations would know our remaining land-based ICBMs are still housed. While one could envision various ways to spoof any access control system, the total spoofing effort and reaction to a spoofing failure should give any organization pause.

Another technological tool is command detonation. This could be installed on both ICBMs and CBMs. Live fire testing could occur with the CBM system. This testing using CBMs would provide confidence for similar usage on ICBMs. By showing our ability to terminate a CBM in flight, both the U.S. and other nations would know that all bets are not off if a CBM or ICBM is in flight. This type of device might come into play during negotiations while in armed conflict or in the case of an in-flight malfunction. Command detonation could prevent variations of the Chinese Embassy bombing during the Kosovo conflict, where target identification is found to be wrong after launch and the missile is still in flight. CBMs could also provide in-flight status – bombs that squeak – providing means to get warhead targeting and health status.[42] This would be useful for providing information to allies and bystanders concerning the intended target, or at least whom it is not pointed to.

The choice of CBM propulsion systems would make is easier to discern a CBM from another ICBM. All modern ICBMs use solid propellants. When burning, they give off an identifiable infrared signature. If a CBM used some other kind of propulsion, such as a scramjet or liquid rocket engine, the heat signature would be noticeably different to a sophisticated sensor.

RESOLVE

As we mentioned in the last section, the START treaty allows for 1600 land-based missiles for the United States. If the U.S. trades nuclear missiles for CBMs, the U.S. should declare outright that it is deploying CBMs, then aggressively test the system during and after deployment. In other words, continuous consistent CBM testing should become the norm. If the U.S. counts on the CBM as a method

to conduct aggression, there must be confidence in the system. And other peers and adversaries must know the U.S. will have the experience and the will to use this weapon. In contrast, none of our deployed ICBMs has ever flown out of their operational silos, much less simultaneously.

To make CBM usage less provocative, the United States could declare to the world that CBMs are a part of our war fighting doctrine, to include testing and training with U.S. forces. Operational testing prods and coaxes world attitude, while not into acceptance, eventually into a state of reduced anxiety. One does not fear the known - one fears the unknown. Conducting consistent periodic CBM testing would be a step towards reducing tensions.

Moreover, testing from a CBM base that is configured as a soft site facility, rather than a hard site, would allow compliance with the START treaty. START stipulates ballistic missiles cannot be launched from soft site facilities unless it is a testing facility.[43] Our other strategic platforms both practice and deploy from the same base. CBMs should be no different. Counterforce strikes are a possibility, but this is already true for U.S. long range bomber bases.

ON SITE INSPECTIONS

International inspections should defuse concerns that a CBM facility is actually a covert ICBM base. As any CBM would be a new ICBM under the START treaty, the U.S. must comply with this START provision, one being the identification and inspection of missile production facilities. The U.S. is barred by the START treaty from producing new heavy ICBMs, ballistic missiles capable of throwing more than 8000 kg.[44] The Russians would need access to verify this fact and for verifying the types and number of available warheads, as per the START treaty. A single soft site CBM launch area requires opening it to inspection as specifically mentioned in START. Accordingly, the CBM deployment area location could not be kept a secret. The U.S. would want those nations who could target us with nuclear arms to know that the CBM location had no nuclear, chemical, or biological weapons. The opportunity to open an operational CBM facility should be welcomed, as it is another step towards reducing tensions. Granted, with clip-on nuclear warheads conceivable, simply opening a base for short notice inspections does not prevent foreign anxiety over a CBM launch. However, every bit helps. Our potential adversaries can take comfort that fissile weapons production is an activity monitored relatively easily.

REMOTE BASING

One proposal to limit CBM deployment to four CBMs per coast seems absurd.[45] Eight CBM airframes, for the political costs involved, is not acceptable. While the idea that ICBM sites make poor CBM sites makes sense (besides being barred by START), it should not limit consideration of geographic regions that previously contained ICBMs. For example, White Sands Missile Range was home years ago

to the Atlas ICBM. If START III becomes a reality, and the last of the Minuteman missiles are deactivated, the Grand Forks area (but not the missile complexes themselves) becomes available. Of these two sites, Grand Forks area is more desirable because of its remoteness. The Grand Forks site does not have the diverse test and scientific activity or population density of White Sands. Moreover, the area has an installation ready for conversion, Grand Forks Air Force Base (AFB). A CBM system could be deployed at the Grand Forks AFB. There is plenty of open territory there and no missiles were deployed on the base. Any new CBM would launch from a tarmac rather than a silo, to allow "show-of-force" presentations via orbital reconnaissance. The facility is already government property, so land use conflicts should not arise. Also, the Grand Forks site also provides roughly equal distance from the coastlines, simplifying booster burn flight mechanics and first stage recovery, if so equipped.

NATIONAL MISSILE DEFENSE

The North Dakota basing has another advantage. Besides being remote and available, a Grand Forks CBM site would be collocated with the proposed national missile defense (NMD) site.[46] Besides site protection, collocation with NMD provides the appearance that the CBM facility is not a "decapitation' weapon. A decapitation weapon, by the Russian definition, does not need protection since the weapons would be loosed all at once. This characteristic is more important than the protection the ABM site provides.

To insure CBMs are not viewed as a prelude to nuclear strike or that they are first strike weapons in the nuclear sense, an NMD system needs deployment, either in the Grand Forks AFB area or elsewhere.[47] CBMs could also be used for testing the proposed NMD system under actual field conditions.

SHARED EARLY WARNING

One proposal increasing the acceptability of CBM deployment is shared early warning between the U.S. and other interested nations. Shared early warning (SEW) is a concept where the earth is monitored via space and land-based electro-optical and radar sensors. This would allow for continuous monitoring of all rocket and jet traffic around the globe.[48]

Our primary partners in the shared early warning system would include China, Russia and other nuclear and economic powers. The network would rapidly track any launch of a CBM, and our partners would be assured the launch was not a nuclear missile. This is more than a “trust me”, since the system would show origination was not from an ICBM field and, these partners would have also inspected our CBM facilities. And do not forget that our early warning partners would have already tested the SEW system integrity, by any number of means. These partners would also trust the system because they

would have a hand in its operation and maintenance. This is not so farfetched – the U.S. has already offered to sell radars and ABM systems to Russia. Why not also operate the SEW together, like what was done for the millennial computer rollover at Colorado Springs between the U.S. and Russia? Shared early warning thus removes the surprise factor, discouraging escalation in a crisis or theater war.[49]

Even if hostilities broke out between two partners, such as the U.S. and Russia, neither side would have a real advantage in CBM tracking. For example, if we were to shoot CBMs in support of Georgia in a war against Russia, the Russians could not do anything to stop us from launching our CBMs based on a shared early warning (SEW) detection. Rather, it would be in our interest to let the Russians know we were firing a CBM. Fixed or relatively immobile targets, the primary target for CBMs, cannot be relocated within thirty minutes; consequently, a SEW partner involved in conflict with us would not have an advantage. Short of having an NMD system, there would be nothing to do but watch.[50]

The infrastructure for a future SEW system is being developed now. It would behoove the U.S. to ensure its requirements for land and space-based monitoring are sufficient for the next 20 years or so. For example, it is unlikely that the current Space-based Infrared Low and High systems' operational requirements documents include the possibility for tracking large volumes of space and air traffic.[51] Essentially, the ability to share space-based intelligence is more procedural than technological.

FAILURE IN NUCLEAR STEWARDSHIP

We may need CBMs. As the U.S. nuclear stockpile ages, they are difficult to maintain, while conventional weapons keep getting better. Moreover, natural physical processes may preempt serious use of significant nuclear arsenals in mothball or reserve status, regardless of our current nuclear weapon stewardship efforts.

Conventional wisdom holds that our current nuclear stewardship program will maintain the safety and efficacy of our nuclear stockpile. However, a recent discovery could complicate nuclear weapons stewardship. Plutonium dioxide is critical for the long-term storage of plutonium because of its long-term stability. PuO_2 reacts with humid air and water to further oxidize. While not directly affecting weapons (which contains Pu^{241} in pure form), it does affect the defense infrastructure around plutonium.[52]

Besides, conventional explosives keep getting better. The recent development of an explosive called octanitrocubane (considered 25% more powerful than HMX, or twice as powerful as TNT) is an example.[53] As an added advantage, cubane derivatives and their by-products are environmentally friendly.

Though its unlikely the U.S. will completely disarm itself of nuclear weapons, it may find the long term costs of nuclear maintenance prohibitive - making CBM an increasingly attractive alternative to nuclear deterrence, especially with alternative explosives becoming available.

ESCALATION MIDDLE GROUND

So, the U.S. will not be giving up its nuclear weapons totally any time soon. Does the fact that the U.S. has non-nuclear strategic weapons, with clear intentions for their use, increase doubt that an incoming missile has a nuclear warhead?[54] "Yes" is the obvious answer. But more important is the likelihood that the use of non-nuclear strategic weapons makes the use of nuclear weapons more untenable. Even if both sides have CBMs (an eventual truism), we still lower the chances of nuclear war by adding another level of escalation. Without CBMs and other PGMs like them, the only response option to a losing campaign, or preempting a future one, would be the use of nuclear weapons. This seems to have been the Soviet view of the European theater. So, the development and use of CBMs and PGMs in general makes the likelihood of a nuclear war less rather than more likely.

It is time to admit nuclear weapons are the wrong means for restraining aggression carried out by conventional weapons, especially when precision weapons can achieve the same ends.[55] CBMs create an alternative means between the two extremes of conventional mobilization and nuclear strikes. Paul Warnke advocates the U.S. announcing at a disarmament conference a new American position of not using nuclear arms first and no use except in retaliation for a nuclear attack on the U.S. or its allies.[56] On the more positive case for CBM, consider how conventional deterrence may be increased through their use. Our enemies may fear our conventional response more than a nuclear one. Phil Williams in his essay Conventional Strategic Weapons makes the argument that that PGMs exploit existing vulnerabilities, rather than create new ones.[57]

With a CBM system in place and with strong conventional PGM forces, the U.S. should announce outright that its nuclear weapons would only be used when the fundamental existence and territorial integrity of the American way of life is threatened.

In supporting their cause, CBM proponents argue that we should adapt a policy against the use of CBMs on declared nuclear powers. Not only does this proposal fail the common sense test, it does not address the problem of maneuvering reentry vehicles. The payload of a CBM will have to be a maneuvering one to achieve the goal of 1-meter targeting error. The cross range capability of a maneuver-capable reentry vehicle is several hundred miles, which does not include the possibility of the payload having a high performance air-breathing engine as part of the end-game package. Because of this possibility, the Chinese, the Indians, or the Pakistanis would not be assured that an incoming CBM is

not meant for them, just because its current exo-atmospheric trajectory places the impact point in Afghanistan. Once in the atmosphere, the warhead could economically zig in cross-range - making our SEW partners nervous. Another reason for placing nuclear capable nations on the target lists is that the types of targets we expect to use the CBM against are more likely to be in these countries. It does not make sense to field a system where the majority of the potential targets are off limits.

SUSTAINED PERIODIC TESTING

If CBMs are on par with other types of conventional systems, CBM readiness cannot be viewed as similar to ICBM readiness. No operational ICBM ever left its silo. CBMs would have a different employment scheme. This could be used as a method to reinforce international acceptance and credibility of CBMs.

The U.S. could reduce surprise and increase conventional deterrence by conducting periodic test launches from CBM launch facilities. These launches would provide potential adversaries with the opportunity to acclimate by seeing a ballistic missile coming over the horizon from U.S. soil. This would reduce the chance of an identification error. We would rather have a nuclear weapons capable adversary practice distinguishing a CBM from an ICBM in peacetime, rather than during an on-going conflict with them or their neighbors. At least in the U.S. and Soviet models, nuclear forces typically have procedures that are followed during contact with unknown intelligence. Especially during a crisis, coupling between various intelligence sources and actual nuclear weapons release tightens, increasing the chance of an accident. Therefore, allowing potential adversaries to get a handle on U.S. CBM launch signatures makes sense. As for adversaries creating counter measures and defenses, that is a tough business, as any national missile defense opponent would claim.[58]

COMMERCIAL SPACE ACTIVITIES

The final argument for deploying CBMs is that rockets will be common place in the near future. The private sector is studying and funding the construction of more private launch vehicles. It is said that by 2015, at least 50 and maybe 200 countries, corporations, and other concerns will have the capability to launch payloads into space. This will force the international community to change its procedures (specifically, shortening or eliminating the launch notification requirements) for launching space launch vehicles.

CBMs will be able to operate because the background "noise" will already exist to allow launching CBMs without creating a panic. The U.S. will not have to manufacture launch rates from CBMs testing to have the desired effort of reducing anxiety; the commercial sector will do that for them. Given a potentially daily launch schedule, space faring nations will have to have systems in place to monitor and

track launches, instantly knowing whether the vehicle is actually a nuclear missile from Wyoming, an express shipment bound for Delhi, or a sub-orbital joy ride for the idle rich. There are dozens of commercial airline flights to the States from foreign states. Why are they not searched prior to departure; or as a minimum, given an escort once inside American airspace? We do not because we accept the risk in exchange for commerce. Both ourselves and the rest of the world will allow regulated and impromptu space flight because we will be better off financially, materially, and culturally.

FRAME OF REFERENCE

Lest the reader comes away thinking the CBM is a panacea, here are some facts related to CBMs. B-52s carried 27,500 tons of weapons to their targets in Desert Storm.[59] That is more than 3000 CBM launches given an 8000-kilogram payload limit. CBMs, as envisioned, will never carry that much ordnance to the fight, regardless of the technology. Also, cruise missile strikes early in the Kosovo air campaign spiked at forty per day.[60] While a properly design and tested CBM facility could handle a missile launch every thirty minutes, it is doubtful it would because of the other theater PGM assets we are likely to have.

A more likely role for CBMs would be performing missions where air superiority is required but not achieved, such as the case with direct attacks with B-52s or where we do not wish risking a B-2 airframe.[61] Of course, CBMs would be used on missions without risking human life. We look back to Desert Storm for an example CBM mission, when B-52s flew 14,000 nautical miles on a 35-hour non-stop mission from continental U.S., delivering 35 AGM-86C against Iraqi ADA positions.[62] Four or five CBMs with maneuvering warheads could handle this type of mission.[63]

CONCLUSIONS

There is an alluring aspect to the conventional ICBM - epitomizing the Air Force vision of global reach, global power. But the CBM has so much in common with ICBMs that one cannot truly separate it from its "older brother". The CBM may have the perception of being a first strike weapon in the nuclear weapons sense. Other nations, either in the fight or as onlookers, may mistake the weapon for an ICBM, replying using their own weapons, which could include weapons of mass destruction. It could encourage an arms race with our aggressive peers, and stir up controversy over the weapons basing, its costs, and how it affects our nuclear posture. The system may even end up inadvertently dropping spent rocket boosters on our population. All these problems are created while producing a weapon that really provides just another (albeit long range) weapon into the PGM mix which does not fundamentally change how we fight.

To take advantage of the CBM, one needs them operating in a world different from the current one. As the CBM is the result of nuclear weapon delivery vehicle development, it is linked to nuclear weapon posture. This posture needs to change. The U.S. would have to exchange nuclear weapons for CBMs. We would have to aggressively promote and enforce nuclear weapon deproliferation and arms control.

CBMs might be deployed once the U.S. has given assurances that it will not use nuclear weapons first, and because the U.S. has reduced its nuclear arsenal well below START III. If a missile defense capability protects the CBM site and the surrounding United States, that would support the impression that CBMs are not precursor weapons in a first-strike nuclear exchange with Russia or another nuclear weapon state. The currently proposed NMD system may fulfill this role. A global space-based and ground-based surveillance system shared with all interested nations would provide considerable collective security and would prevent misidentification when and if CBMs and other long range weapons are used in conflicts. The international community will tolerate long range PGMs like the CBM used in war because it reduces the likelihood of a nuclear war.

CBMs could eventually become a part of a conscious non-nuclear weapons war fighting strategy for the U.S. With this strategy, CBMs will be deployed when they are cost-effective as compared to other long range strike options, becoming one weapon of many in a complete PGM arsenal. Finally, the world is changing with or without CBMs. The international community will become accustomed to rockets flying into space at random times from random places with no notice. Time will tell if this new world arrives.

WORD COUNT = 8015

ENDNOTES

[1] Airpower Journal, Fall 1997, Volume XI, No. 3, AFRP 10-1, Robert Gibson, MAJ USAF, "Conventionally Armed ICBMs.

[2] London, John, Lt. Col. USAF "The Ultimate Stand-off Weapon", Air Power Journal 7, no. 2 (Summer 1993): 58-68.

[3] "The Role of the Conventional Intercontinental Ballistic Missile in the United States Military Strategy", Thesis, Fort Leavenworth, KS 1995.

[4] Private conversation with Dr. David Jablonsky, an Army War College faculty member, concerning the SALT talks, January 2000.

[5] Patenaude, Richard M., A Thesis, "The Role of Conventional Intercontinental Ballistic Missiles in the Unites States Military Strategy," Command and General Staff College, Fort Leavenworth, Kansas, 1995, pp. iv.

[6] Ritchie, George, and Haaren, John, "Striking from Space: The Future of Space Force Applications," AIAA-98-5257.

[7] Defense Daily, 22 Jan 1999, by David Atkinson, "Air Force Continues Pursuit of Conventional ICBMs."

[8] Aviation Week and Space Technology, Oct 1999, "Air Force Weighs Multi-Role ICBM."

[9] Fulghum, David, "F-117 Pilots, Generals Tell Congress About Stealth's Value in Gulf War," *Aviation Week and Space Technology*, Vol. 134, No. 18, May 6, 1991.

[10] Latter, Albert L., Martinelli, Ernest A., Speed, Roger D., *Conventional Strategic Deterrence*, UCRL-ID-111265, August 1992, LLNL, Livermore, CA, pp. 5.

[11] CBMs could carry cluster, penetration, or fuel-air weapons - the same type weapons carried by air breathing platforms.

[12] Thirty minutes from the continental U.S. to Russia is a typical number cited.

[13] What about submarine launched cruise missiles? They do not need overseas support if they do not run out of food, something that this author has experienced while deployed on a submarine.

[14] Sharfman, Peter J., "The Future of Land-based Strategic Weapons: Part I," *New Technology and Western Security Policy*, edited by Robert O'Neill, The Shoe String Press, Hamden, 1985, pp. 16.

[15] Beach, Hugh, "Inadvertent Nuclear War? Escalation and NATO's Northern Flank," *Bulletin of the Council for Arms Control*, Vol. 7 No. 2, Fall 1982, p. 50.

[16] "1995 sounding rocket flight reportedly triggered Russian alert," *Aerospace Daily*, Vol. 187, No. 8, pp. 69.

[17] Bracken, Paul, "Warning and Intelligence," *The Command and Control of Nuclear Forces*, Yale University Press, New Haven, 1983, pp. 66.

[18] Bracken, Paul, "Warning and Intelligence," *The Command and Control of Nuclear Forces*, Yale University Press, New Haven, 1983, pp. 54.

[19] The so-called "dead hand" as described by Bruce G. Blair.

[20] Blair, Bruce G., *Global Zero Alert for Nuclear Forces*, Brookings Occasional Paper, The Brookings Institution, Washington, D.C., pp. 45-46, 51-52.

[21] It is thought the Chinese do not yet have a global missile warning surveillance network.

[22] Huxley, Tim, "Emerging Technology: No Conventional Wisdom," *New Conventional Weapons and Western Defense*, edited by Ian Bellany and Tim Huxley, (Frank Cass and Company Limited: Totowa, New Jersey, 1987), pp. 178.

[23] Lookwood, Jonathan S. and Lookwood, Kathleen O., "Appendix C – The Impact of Ballistic Missile Defense on Operational War," *The Russian View of U.S. Strategic: Its Past, Its Future*, Transaction Publishers, 1993, pp. 217.

[24] In the cold war days, nuclear weapons were to be used against ICBM missile fields. The warhead just had to get close enough to the silo to destroy the missile inside. With a penetrator-equipped CBM, any hit within a 1-3 meters will do the same thing without expending nuclear energy and the lack of fallout.

[25] Patenaude, Richard M., A Thesis, "The Role of Conventional Intercontinental Ballistic Missiles in the Unites States Military Strategy," Command and General Staff College, Fort Leavenworth, Kansas, 1995, pp. 81.

[26] Garrett, Banning N. and Glaser, Bonnie S., "Chinese Perspectives on Nuclear Arms Control," *International Security*, Vol.. 20, no. 3, pp. 66.

[27] Sinhg, Nrendar, "Chinese Armed Forces," U.S.I. Journal, October-December 1991, pp. 600-601.

[28] Karp, Aaron, "The New Politics of Missile Proliferation," *Arms Control Today*, Vol. 26, No. 8, pp. 14.

[29] Vandenburg AFB, the Point Magu area.

[30] Moreover, having two facilities probably is not required. Other than the distance from launch to target, of what value do two CBM sites bring? Proposed scenarios for using CBM do not stress the launch rate enough to justify having two sites. Automation within a single site may more than double launch rates, obviating dual siting.

[31] Contact the Ballistic Missile Defense Organization test community for details.

[32] London, pp. 66-68.

[33] London's build-to-cost for launch vehicles is another name for an old concept – the Big Dumb Booster. Its premise is the use of low cost designs based on the ease of manufacturability, rather than performance. In contrast, ICBMs need to work right the first time, so little expense is spared to insure the vehicle works as intended.

[34] For a recent example of this magic number, see "Space giants step up efforts to win low-cost launch race," *Jane's International Defense Review,* Vol. 33, March 2000, pp. 32.

[35] U.S. Arms Control and Disarmament Agency, Fact Sheet - Reductions in US and Former Soviet Union Nuclear Weapons, Washington, D.C. 30 April 1992. One can calculate upper and lower limits, assuming no heavy bombers, of 1300 to 1750 respectively. See http://www.armscontrol.org/FACTS/start2.html.

[36] Builder, Carl H., "The Prospects and Implications of Non-nuclear Means for Strategic Conflict," Adelphi Papers, #200, The International Institute for Strategic Studies, 1985, pp. 4.

[37] Builder, pp. 22.

[38] Dingli Shen, "China," *Nuclear Weapons after the Comprehensive Test Ban - Implications for Modernization and Proliferation*, edited by Eric Arnett, pp. 28-29. However, this is the same China that asked if the U.S. would trade Los Angeles for Taiwan.

[39] Builder, pp. 14.

[40] The North Korean Taepo-dong missile is generations away from a CBM capability, assuming the regime survives. The Chinese seem to believe they cannot match U.S. technology. And faced with this fact, China pursues war by other means. The Russians do not and will not have the resources to develop and field the CBM alternative; having difficulties enough sustaining their current nuclear posture, much less building precision CBM artillery. For now, the Russians will continue to focus on modernizing their mobile nuclear forces as its primary strategic weapon system which are less than ideal CBM targets.

[41] Karp, pp. 8.

[42] Congressional Budget Office, "Verification," *The START Treaty and Beyond*, October 1991, pp. 98.

[43] A soft-site is any land-based fixed launcher that is not silo-based. The logical of this stipulation is likely related to break-out – preventing the rapid construction and deployment of strategic nuclear weapon delivery vehicles.

[44] US Arms Control and Disarmament Agency, START - Treaty Between the United States and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Defense Arms, Article 2, 1991, pp. 7.

[45] Wall, Robert, "USAF Weighs Multi-Role ICBM," *Aviation Week and Space Technology*, October 18, 1999, pp. 34.

[46] Besides being a heavy bomber base, Grand Forks AFB was a ICBM maintenance facility - not an ICBM base - and therefore may host CBMs per the START treaty as a "soft-site" test range. The proposed National Missile Defense System is near Concrete North Dakota.

[47] An NMD site may also be placed in Alaska. This would also be a possible location for CBM deployment.

[48] That said, it is surprising the Defense Science Board claimed vehicles could launch from U.S. soil undetected. If true now, this fact will not be true in the near future. See Report of the Defense Science

Board Summer Study Task Force, 'Joint Operations Superiority in the 21st Century,' ADA364142, October 1998, Vol. 1, pp. 30.

[49] Williams, Phil, "The Nuclear Threshold in Europe and Emerging Technologies," *New Conventional Weapons and Western Defense*, edited by Ian Bellany and Tim Huxley, pp. 172.

[50] There also could be blocking requested by a SEW partner if its warfighting assets over a theater, say, the U.S. blocking its warcraft over the Balkans, or Russia over the U.S. Each SEW partners would likely have its own surveillance system in toto with SEW.

[51] More commonly known as SBIRS-High and SBIRS-Low, rhymes with scissors. An excellent article on the subject of openness, the essence of shared early warning, ran in the New York Times.

[52] Madic, Charles, "Toward the End of PuO_2's Supremacy?," *Science*, Vol. 287, No. 5451, pp. 243-244.

[53] Wu, C., "Powerful explosives blasts onto scene," *Science News*, Vol. 54, No. 4, pp. 54.

[54] Builder, pp. 22.

[55] A former Air Force Chief of Staff, General Ronald Fogelman, believes PGMs can be as effective as nuclear weapons. See Messrs. Krepinevich and Kosiak "Smarter bombs, fewer nukes," *The Bulletin of Atomic Scientists,* Vol. 54, No. 6, pp. 29.

[56] Warnke, Paul C., "Strategic Nuclear Policy and Non-Proliferation," *Arms Control Today*, Vol. 24, No. 4., pp. 5.

[57] William, Phil, "The Nuclear Threshold in Europe and Emerging Technologies," New Conventional Weapons and Western Defense, edited by Ian Bellany and Tim Huxley, (Frank Cass and Company Limited: Totowa, New Jersey, 1987), pp. 174.

[58] The attacker holds the advantage in an intercontinental missile exchange, not the defender. Besides, it has been stated by at least one administration that the U.S. would be willing to sell ABM systems abroad.

[59] Chilstrom, John S., "Global Reach? Air Force Capabilities for Long Range Attack," SRP, Class of 1997, pp. 7.

[60] Clark, Wesley K., "The United States and NATO: The Way Ahead," *Parameters* (Winter 2000, p. 10.

[61] Chilstrom, John S., "Global Reach? Air Force Capabilities for Long Range Attack," SRP, Class of 1997, pp. 11.

[62] Dana Johnson, "Roles and Missions for Conventional Armed Heavy Bombers: A Historical Perspective." (Santa Monica, CA: RAND, 1994), pp. 85.

[63] START limits multiple reentry vehicles to ten. Maneuvering reentry vehicles are more bulky than multiple independently targeted reentry vehicles, reducing the number of warheads per flight vehicle.

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